



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁴ : C07K 13/00, C12P 21/02 C07K 7/10 // A61K 37/38 C07K 3/20	A1	(11) International Publication Number: WO 88/ 10270 (43) International Publication Date: 29 December 1988 (29.12.88)
(21) International Application Number: PCT/IT88/00048 (22) International Filing Date: 24 June 1988 (24.06.88) (31) Priority Application Number: 48110 A/87 (32) Priority Date: 26 June 1987 (26.06.87) (33) Priority Country: IT (71) Applicant (for all designated States except US): ISTITUTO DI RICERCA CESARE SERONO SPA [IT/IT]; Via Valle Caia, 22, I-00040 Ardea (IT). (72) Inventors; and (75) Inventors/Applicants (for US only) : ARPAIA, Giuseppe [IT/IT]; Via S. Erasmo, 10, I-00184 Roma (IT). SERANI, Serenella [IT/IT]; Via Antonio Lo Surdo, 41, I-00146 Roma (IT). SIRNA, Antonino [IT/IT]; Via dei Monti di S. Paolo, 126, I-00126 Roma (IT). VILLA, Stefano [IT/IT]; Via Oslavia, 37, I-00195 Roma (IT).		(74) Agent: VANNINI, Mario; Istituto Farmacologico Serono SpA, Via Gregoriana, 38, 4th Floor, I-00187 Roma (IT). (81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK, FI, FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), NO, SE (European patent), SU, US. Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: URINARY FOLLICLE STIMULATING HORMONE (57) Abstract Purification of human FSH from post-menopausal urine gonadotropin using immunochromatography and reverse phase HPLC steps yields a biologically active hormone which is free from detectable traces of LH and other urinary proteins.		

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URINARY FOLLICLE STIMULATING HORMONEField of the invention

This invention relates to urinary follicle stimulating hormone, to pharmaceutical compositions containing it and to a method for its purification.

Background of the invention

Follicle stimulating hormone (FSH) is known to be useful in the treatment of infertility. Preparations containing this hormone have been employed to assist in effecting pregnancy using both in-vivo and in-vitro techniques. Human FSH has been isolated from human pituitary glands and from post-menopausal urine. More recently, it has been produced using recombinant DNA techniques.

The first commercially available product comprising human FSH contained HMG (e.g., Pergonal^(R) Serono), i.e., human menopausal gonadotropin extracted from post-menopausal urine which is a mixture of FSH, Luteinizing Hormone (LH) and other urinary proteins. Meanwhile, several attempts were made to obtain pure FSH preparations, both for scientific and therapeutic purposes. The product Metrodin^(R) (Serono), currently available in commerce, is a preparation of urinary FSH containing other urinary proteins, but minimum quantities of LH and is used for the treatment of infertility. Use of this product is particularly advantageous when administration of exogenous LH together with FSH is undesirable, e.g., in the polycystic ovary syndrome (PCOS).

So far, administration of FSH for therapeutic purposes has been carried out, successfully, exclusively by intramuscular injection. Since intramuscular injections are generally performed by the physician or by the medical professional staff, the patient is expected to visit a surgery or a

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hospital regularly in order to receive the treatment. This creates a considerable discomfort. Moreover, the time taken up by this type of application often leads to unsatisfactory compliance by the patient as the
5 treatment normally extends over several weeks or months.

Administration by subcutaneous injection would render possible the self-administration by the patient and consequently improve patient's cooperation and
10 compliance.

The subcutaneous administration of Human Menopausal Gonadotropin (HMG) has already been described (Nakamura Y. et al., Fertility and Sterility, 46(1):46-54, 1986) in connection with the treatment of
15 female infertility by pulsatile administration of HMG via the subcutaneous peristaltic pump. The subcutaneous administration may suffer the drawback of the appearance of local allergies due to the presence of impurities in the product used and, consequently,
20 result in the suspension of the treatment.

P. Roos ("Human Follicle Stimulating Hormone", Acta Endocrinologica Supplementum 131, 1968) described and characterized highly purified preparations of pituitary and urinary FSH obtained from frozen
25 pituitaries and from post-menopausal urinary concentrate, respectively. Biological potencies as high as about 14,000 I.U. of FSH activity per mg for pituitary FSH and 780 I.U. of FSH activity per mg for urinary FSH were obtained. The content of LH
30 contamination in the most active pituitary and urinary preparations was estimated to correspond to approximately 0.1 per cent by weight. The purification procedures involved one or more of such techniques as chromatography on DEAE-Cellulose, gel-filtration on
35 Sephadex G-100, hydroxylapatite chromatography, polyacrylamide gel electrophoresis, and the like.

One of the best purified urinary FSH

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preparations was described by Donini et al.
("Purification and partial Chemico-physical
characterization of FSH from Menopausal Urine",
Gonadotrophins and Ovarian Development (Proceedings of
5 two workshop meetings), E and S Livingstone, Edinburgh
and London, 1970) and had a biological potency of
1255.6 I.U. FSH per mg with an LH contamination as low
as 3.2 I.U. LH per mg.. In this case, the starting
material was a Human Menopausal Gonadotropin (HMG)
10 preparation (Pergonal^(R)) which, as stated above, is
a mixture of FSH and LH hormones and other urinary
proteins. This result was achieved by batchwise
purification of the starting HMG on DEAE-Cellulose
followed by chromatography on a DEAE-Cellulose column,
15 gel filtration on Sephadex G-100 and a final step of
preparative polyacrylamide gel electrophoresis.

Even higher biological potencies were achieved
by H. Van Hell et al. ("Purification and some
properties of human urinary FSH and LH", Gonadotropins
20 (Proceedings of Int.l Symposium on Gonadotropins,
1971), Wiley - Interscience, New York) by adding
immunochromatography and gel-filtration steps to a
conventional chromatographic purification procedure.
Immunochromatography was performed using anti-HCG
25 antibodies coupled to Sepharose for the specific
purpose of removing the LH activity from partially
purified FSH fractions. The best purified FSH fraction
contained 4720 I.U. FSH per mg and the LH contamination
was as low as 15 I.U. LH per mg as assayed by RIA.

30 The immunochromatographic approach had already
been described by Donini et al. ("Purification and
Separation of FSH and LH from HMG", Acta
Endocrinologica 52, pages 186-198, 1966) who obtained
as early as 1966 an FSH preparation which had a
35 potency of 329.7 I.U. FSH per mg and biologically
undetectable amounts of LH contamination. In another
experiment, a fraction assaying 148.3 I.U. FSH per mg

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and 2.4 I.U. LH per mg was obtained. Since no RIA was performed on the 329.7 I.U. FSH per mg preparation, it can be assumed by analogy with the results of H. Van Hell (c.f. supra) that traces of LH would have been found if assayed by RIA.

The physiological relevance of even minimal amounts of LH contamination was shown by Donini et al. in a paper ("A new approach to the Biological Determination of the Luteinizing Hormone", Acta Endocrinologica, 58, pages 463-472, 1968) where a new bio-assay for LH determination was proposed which consisted in injecting intact immature mice with a constant dose of a biologically pure FSH preparation plus increasing amounts of LH and then measuring the increase in the uterine weight as a response proportional to the LH activity. By this method, as little as 0.068 I.U. of LH were shown to be capable of increasing the uterine weight when injected together with 4.44 I.U. of FSH.

It thus clearly follows that an absolutely pure FSH preparation is desirable when FSH activity in the complete absence of LH activity is requested in therapy.

As mentioned above, the currently marketed product Metrodin^(R) (Serono) is a purified FSH preparation which is obtained by a method substantially identical to that described by Donini et al. in an already mentioned paper (Acta Endocrinologica 52, pages 186-198, 1966). The quality control specifications, in agreement with the declared biological purity of the said preparation, provide for not more than 0.7 I.U. LH per 75 I.U. of FSH, i.e., approximately the sensitivity limit of the biological assay. In certain therapeutic applications, however, the absolute absence of LH is desirable. Furthermore, in Metrodin^(R), human FSH is accompanied by substantial amounts of other urinary proteins, i.e., it is not a chemically

pure FSH preparation.

U.K. patent application 2,173,803 A provides still another approach to the purification of pituitary glycoprotein hormones, among them FSH. This approach
5 consists of first forming a complex of the hormone with immobilized monoclonal antibodies and then eluting the hormone with an acidic aqueous buffer having a pH from 3 to 4. As far as FSH is concerned, the obtained highly purified hormone is still contaminated with 0.1% by
10 weight of LH and 0.5% by weight of TSH.

Scott C. Chappel et al. describe in a review article (Endocrine Reviews 4(2), 179-211, 1983) the microheterogeneity of FSH and the physiological
15 significance of the carbohydrate moieties accompanying the FSH molecule. The hypothesis can be formulated that some modifications occur during the metabolic pathway up to the final urinary secretion which may account for the chemico-physical differentiation
20 demonstrated in the experiments carried out by Applicant between the highly purified urinary FSH preparation (hpuFSH) according to this invention, and the highly purified pituitary FSH preparation used for comparison purposes.

Co- or post-translationally modifications
25 appear to be the basis for microheterogenous diversity of FSH, a glycoprotein consisting of two dissimilar, glycosylated, non covalently linked polypeptide chains known as alpha and beta-subunit. The beta-subunit endows the molecule with its biological specificity.

30 Incidentally, the same article attempts to explain the substantial difference in the values of biological activity per mg between highly purified pituitary and urinary FSH preparations. A reasonable hypothesis can again be based on the relevance of the
35 carbohydrate moieties and, more specifically, the role of the terminal sialic acid residues.

It should be noted that, while both pituitary

FSH and urinary FSH are termed "FSH", no conclusive evidence has yet been found which verifies whether the molecules isolated from the two sources are the same or even chemically equivalent.

5

Description of the invention

It has now been found that human urinary FSH can be isolated from a concentrate of post-menopausal urine to such a degree of purity that the resultant FSH is completely free from any detectable traces of LH and other urinary proteins. Furthermore and contrary to any expectation, the amino acid analysis of the urinary FSH according to the present invention has revealed a novel FSH beta-subunit of 111 amino acids instead of 118 or 108 as reported in the state of the art (see e.g. Scott et al. supra) for the known FSH beta-subunit. More specifically, this invention provides a novel FSH beta-subunit, the amino acid sequence of which is as follows:

20

10

Asn Ser Cys Glu Leu Thr Asn Ile Thr Ile Ala Ile Glu Lys

20

Glu Glu Cys Arg Phe Cys Ile Ser Ile Asn Thr Thr Trp Cys

30

40

25 Ala Gly Tyr Cys Tyr Thr Arg Asp Leu Val Tyr Lys Asp Pro

50

Ala Arg Pro Lys Ile Gln Lys Thr Cys Thr Phe Lys Glu Leu

60

70

Val Tyr Glu Thr Val Arg Val Pro Gly Cys Ala His His Ala

30

80

Asp Ser Leu Tyr Thr Tyr Pro Val Ala Thr Gln Cys His Cys

90

Gly Lys Cys Asp Ser Asp Ser Thr Asp Cys Thr Val Arg Gly

100

110

35 Leu Gly Pro Ser Tyr Cys Ser Phe Gly Glu Met Lys Glu

as well as a novel protein comprising the known

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gonadotropin alpha-subunit and the 111 AA beta-subunit as hereabove defined. The protein has follicle stimulating hormone (FSH) biological activity. Preferably it is in glycosylated form. Most preferably
5 it is substantially free from detectable traces of luteinizing hormone and other urinary proteins.

A further aspect of the invention is a pharmaceutical composition containing a purified protein according to the present invention and a
10 pharmaceutically acceptable excipient. Preferably the composition is in a form suitable for subcutaneous administration. It has been found that subcutaneous injection of a pharmaceutical composition according to the present invention does not give rise to the
15 appearance of those allergical reactions normally encountered with the known FSH preparations.

According to a further aspect of this invention, a method is provided to produce the novel and highly purified FSH according to the present application. The
20 method is substantially based on the combination of an immunopurification step with reverse phase HPLC. The immunopurification step uses immobilized monoclonal antibodies substantially as described in the above mentioned U.K. patent application 2,173,803A, but with
25 the fundamental difference that elution of FSH from the immunocomplex is carried out at much higher pH values.

In the process of the present invention elution is conveniently carried out using an aqueous solution
30 having a pH higher than about 10 and a molarity higher than about 0.5. The experiments carried out by Applicant have shown that, in these conditions the immobilized antibody is not substantially inactivated. This is in contrast with the teaching of the above
35 mentioned U.K. patent application which states (on page 1, lines 36 - 37) that "the use of eluents having such high pHs is not feasible in practice since it

leads to rapid inactivation of the antibody".

This difference in behaviour may depend upon differences in the methods adopted to link the antibody to the resin.

5 According to this invention, the pH of the eluent is preferably higher than 11 and more preferably comprised within the range of 11.3 to 11.7.

Molarity values are preferably higher than 0.8 and more preferably of about 1.

10 Suitable eluents for use in the invention process are ammonia, diethylamine and such buffers as TRIS buffer, glycine-NaOH and the like.

The subsequent reverse phase high pressure liquid chromatography (HPLC) step permits one to obtain
15 the complete removal of any contaminating proteins. This removal is not achieved by the immuno-purification step alone, as is also acknowledged in the U.K. application text. The fact that such a step not only effectively removes the residual traces of
20 contaminating proteins but also retains all the FSH biological activity is surprising in view of the article by P. Hallin and S.A. Khan (J. Liq. Chromat. 9(13), 2855-68, 1986) which shows loss of biological activity for bovine FSH and for human FSH (standard of
25 HMG) when they are subjected to reverse-phase HPLC. On the other hand, the same article shows a satisfactory recovery of biological activity, but only partial separation, when the human urinary preparation (i.e., containing both FSH and LH) is subjected to ion-
30 -exchange HPLC.

Following the HPLC step, FSH is recovered using conventional techniques. For storage and/or handling purposes, the product can be lyophilized. Other
suitable procedures to effect concentrating,
35 stabilizing or other processing of the product are contemplated.

Clearly, the availability of post-menopausal

urine is greater than that of human pituitary glands. This relative availability lends dramatic importance to Applicant's discovery.

The FSH-specific monoclonal antibody for use in the process of this invention may be produced using known techniques.

In a typical example, hybridoma cell line 9/14 was screened for optimal affinity towards FSH at the University of Cambridge. Monoclonal antibodies were produced in supernatant medium by cell culture techniques and purified by means of salt fractionation using 50% (w/v) ammonium sulphate followed by ionic reverse-phase chromatography and HPLC gel filtration and dialysis.

The monoclonal antibody produced by cell line 9/14 and purified as described above had the following specifications:

- a) protein purity: not less than 90%
- b) class of immunoglobulin: IgG 1
- c) affinity constant: $3.5 \times 10^8 \text{ L.mole}^{-1}$
- d) specificity:

	<u>Antigen</u>	<u>% cross reaction</u>
	FSH	100
25	HCG	1
	HCG-beta subunit	1
	LH	1
	TSH	1

- e) binding capacity to FSH in solution: about 1,000 I.U. FSH per mg McAb.

FSH-specific monoclonal antibodies are chemically bound to Sepharose 4B by divinylsulphone according to the method described by J. Porath in Methods in Enzymology 34, pages 13-30, 1974.

In a typical example, 1 litre of Sepharose 4B was washed on a porous glass filter first with 5 litres

of freshly distilled water and then with 5 litres of 1 M sodium carbonate, pH 11. The washed Sepharose was suspended in 1 litre of 1 M sodium carbonate (pH 11). 200 ml of divinylsulphone were added dropwise with continuous stirring. The reaction was completed in 70 minutes at room temperature and then stopped by means of the addition of 1 N HCl (up to pH 7.0).

The activated resin was suspended in 1 litre of 0.25 M sodium bicarbonate (pH 9.0) containing 2 grams of anti-FSH monoclonal antibody to obtain more than 90% binding of the antibody to the activated resin. The immuno-resin obtained was stored at 4°C.

The following Example 1 illustrates the two purification steps of the method of this invention as applied to commercial HMG, i.e., the active ingredient in Pergonal^(R) Serono.

It is understood that while HMG is the preferred starting material in the invention process, the latter is also applicable to less purified materials such as post-menopausal urine concentrates and the like. Good results have been obtained using as starting material a urinary concentrate containing as low as 1 I.U. FSH per mg.

Other aspects and advantages of the invention will become apparent after consideration of the following examples, which are not intended to be limiting.

EXAMPLE 1: Preparation of highly purified urinary FSH (hpuFSH)

1st Step: Immunopurification on anti FSH McAb-DVS-Sepharose

HMG was used as starting material.

Immuno-resin anti-FSH McAb-DVS-Sepharose was equilibrated in 0.1 M Tris-HCl, 0.3 M NaCl buffer pH=7.5 at 4°C.

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The column was loaded with a quantity of IU FSH (RIA) corresponding to 80-90% of its total FSH binding capacity.

The non-retained proteins were eluted with the equilibrating buffer until the OD₂₈₀ of eluate was lower than 0.02.

The absorbed uFSH was eluted from the immuno-resin with 1 M ammonia solution at 4°C. Ammonia eluates corresponding to about 4 times the immuno-resin volume were pooled, the pH was adjusted to 9.0 as soon as possible at 4°C by adding glacial acetic acid and the solution was ultrafiltered in an Amicon apparatus (membrane C.O. 10,000 Ds) and concentrated to a small volume.

15

2nd Step: Reverse phase HPLC

The resultant solution, adjusted at pH=5.6, was loaded on a C₁₈ reversed phase column (Pre Pak Waters) which had previously been equilibrated with 0.05 M ammonium acetate pH=5.6 buffer at room temperature.

Flow rate was 100 ml/min and the eluate was monitored at 280 nm.

The HPLC purification was carried out employing a Prep 500 A apparatus (Waters) equipped with UV detector and a preparative gradient generator

Biologically active highly purified urinary FSH was eluted by a gradient of isopropanol up to 50% of the mobile phase. Fractions were checked by analytical GPC and RIA.

The organic solvent was removed by distillation under vacuum at 40°C and then the solution was frozen and lyophilized.

35 EXAMPLE 2: Characterization of the FSH

The highly purified urinary FSH preparation of

the present invention was subjected to several chemico-physical, biological and immunological tests in order to achieve its complete characterization. As indicated below, most of the tests were carried out in comparison
5 with a highly purified pituitary FSH preparation obtained according to the procedure described below.

Crude human pituitary extract (HPG), a by-product resulting from extraction of the Human Growth Hormone, was used as starting material.

10

The procedure consisted of the following steps:

- 1) Preliminary purification of crude HPG by
extraction with 40% ethanol containing 6% ammonium
acetate pH 5.6 and precipitation of supernatant
15 with 96% cold ethanol.
- 2) Further purification of HPG by ion exchange
chromatography on DEAE cellulose, using 0.15 M
sodium acetate pH 7 as eluent, followed by
precipitation with 96% cold ethanol.
- 20 3) Further purification of FSH fraction by gel
filtration on Sephadex G-100, using 0.05 M ammonium
bicarbonate as buffer.
- 4) Last step of FSH purification by ion exchange
chromatography on SP Sephadex C 50. Highly purified
25 pituitary FSH was eluted with 0.1 M phosphate buffer
pH 6.2 and lyophilized.

The pituitary FSH in-vivo biological specific
activity (Steelman-Pohley test; I.U. of 2nd IRP-HMG)
30 was determined to be 4770 I.U. FSH/mg of lyophilized
powder using the methodology described below under
"Biological Assay".

The characterization tests performed were as
follows:

35

LH contamination

This test was carried out by means of a specific

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radioimmunoassay for LH using an LH standard calibrated against the 2nd IRP-HMG and ^{125}I -LH as the tracer, both contained in the LH ter KIT (code 10204) currently marketed by the company Biodata (R).

- 5 As antiserum, a sheep anti-HCG antiserum prepared by the Applicant was used having 100% cross-reactivity to LH and less than 0.1% to FSH.

The RIA procedure as per the manufacturer's instructions was followed to obtain as a result no
10 detectable LH contamination in the highly purified urinary FSH preparation prepared in accordance with the Example 1.

The above results were confirmed using a more sensitive assay called DELFIA (dissociation - enhanced
15 lanthanide fluoro immunoassay) marketed by LKB-Pharmacia.

SDS - PAGE

Slab-gel electrophoresis in SDS was performed,
20 under reducing conditions, on 13.5% polyacrylamide gel pH = 8.8 according to the procedure described by Laemmli in Nature, 227, pages 680 - 685 (1970).

Staining was performed with Coomassie Brilliant Blue R-250 0.25% in a 25% methanol / 75% acetic acid
25 solution.

Both the hpuFSH preparation according to the invention and the highly purified pituitary FSH preparation (hppFSH) obtained as described above were subjected to this test. Results are illustrated in
30 Figure 1 where the bands of both the urinary and pituitary FSH preparations (uFSH and pFSH, respectively) are shown together with the molecular weight markers (M.W.).

In both the uFSH and pFSH preparations the main large
35 band typical of the glycoproteins is found at the same molecular weight of approximately 20,000 Daltons, which is also in accordance with the literature data. Due to

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the known behaviour of the glycoproteins in SDS - PAGE, this value is a little overestimated.

Size exclusion chromatography

5 Analyses of both hpuFSH and hppFSH were performed on a TSK G 2000 SW column by LKB using 0.1 M phosphate buffer pH 6.8 + 0.2 M NaCl as the eluent. Flow was 0.7 ml/minute and readings were made at the wavelength of 230 nanometers.

10 Results are illustrated in Figure 2 which shows single main peaks for both uFSH and pFSH with substantially the same retention times (13.37 and 13.55 minutes, respectively).

15 Isoelectrofocusing

 Isoelectrofocusing was carried out on 5% thin-layer polyacrylamide gel (Anpholine LKB^(R), pH range 3.5 to 9.5) fixed in 11.5% (w/v) TCA and 3.5% (w/v) sulphosalicylic acid and stained with a Silver
20 staining BIO-RAD^(R) Kit.

 Results for both hppFSH and hpuFSH are illustrated in Figure 3 which also shows the isoelectric point markers. As can be seen from the figure, both urinary and pituitary FSHs show several
25 bands but completely different patterns; in particular, the main bands of urinary FSH are at a pH range lower than 4.8 whereas pituitary FSH shows the main bands at a higher pH range.

 This test demonstrates that urinary and
30 pituitary FSHs are not identical molecules and that the differences reside at least in their carbohydrate moieties, if not in the protein moieties themselves.

Biological assay

35 The FSH in-vivo biological activity of hpuFSH was tested by the Steelman Pohley method (Endocrinology 53, pages 604 - 616, 1953) using as the reference

- 15 -

material an HMG House Standard calibrated against the 2nd International Reference Preparation of HMG for bioassay. This assay is accepted by all major Pharmacopoeias and Health Authorities for the determination of the International Units (I.U.) of FSH biological activity.

The hpuFSH preparation obtained according to the Example above was determined to have a specific activity of 6200 I.U. of FSH per mg of lyophilized powder, i.e., the highest specific activity ever described for an FSH urinary preparation.

Determination of the Amino Acid sequence

15 a) uFSH Subunit Separation

The separation of the uFSH subunits is performed using a Waters HPLC system equipped with a column Aquapore RP-300, 200 x 4.6 mm, 7 um, (Brownlee Labs).

20 The eluents are A = 0.1% TFA (Trifluoroacetic acid, HPLC grade, Pierce), B = 0.055% TFA in Acetonitrile. The flow rate is 1 ml/min at 35°C and the initial condition is 15% B.

The gradient raised 40% B in 20 min.

25 The UV detector is set at 229 nm.

Usually in analytical runs 20 mcl of a solution 0.5 mg/ml of hpuFSH and 0.5% TFA is injected.

Preincubation in TFA solution is not necessary.

25 The preparative separation is performed using the same column.

30 Good resolution is achieved by injecting 0.5 mg of hp human u FSH (batch n° 032) dissolved in A buffer. Fractions are collected manually and dried down using a Speed Vac concentrator. Subunits are dissolved in water, analyzed by HPLC and stored at -20°C.

35 The beta subunit is eluted after about 10.5 min as

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a broad peak, the alpha subunit elutes at 15 min as a sharp peak.

The recognition of each peak as beta and alpha subunit respectively is accomplished by a specific RIA.

5

Usually the recovery of the beta subunit is around 50%, the alpha subunit recovery on the contrary is more than 90%.

10 b) Reduction and Carboxymethylation of the alpha and beta Subunits.

Reduction of the subunits, separated as described in point a), is performed in 0.5 Tris, 0.1% EDTA, 6M Guanidine HCl pH 8.5 for 2 h at 37°C using DTT (dithiothreitol, Serva)

15

in 15 fold molar excess over cystein content. Sodium iodoacetate (2.1 molar over DTT) is then added to the reaction mixture and left lying for 30 min in the dark.

20 To stop the reaction 1% mercaptoethanol and TFA is added.

The carboxymethylated subunits are purified by HPLC. The beta carboxymethylated subunit is poorly soluble in water so that the final yield is quite low.

25

c) Reduction, pyridylethylation and trypsin digestion of the beta subunit

Reduction of the beta subunit, separated as described in point a) was performed at room temperature for 2 hrs in the following way:

30

0.1 mg of beta subunit 0.5 ml of 0.5M Tris, 0.1% EDTA, 6M guanidine HCl pH 8.5 2.7 mg Dithiothreitol

The Pyridylethylation was performed adding 0.02 ml of 4 vinylpyridine to the previous solution.

35

The reaction takes 2 hrs at room temperature.

Finally, the reaction mixture was loaded onto a C4

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- Cartridge (Baker) equilibrated with 0.1% TFA.
The cartridge was washed with 0.1% TFA and the beta subunit pyridylethylated was eluted with 40% Acetonitrile, 0.1% TFA. The eluted fraction was
5 dried down and purified by HPLC as previously reported for the beta subunit. The pyridylethylated beta subunit previously purified by HPLC was dissolved in 1% NH_4HCO_3 , pH 8.
- 10 The trypsin was added to the solution and the reaction was carried out for 1.5 hrs at 37°C. The tryptic fractions were purified by HPLC using the same procedure previously described, except for the gradient from 0% to 55% in 30' and the UV
15 detector, set at 214 nm. The tryptic fractions were sequenced in the same way reported for the sequencing of the subunits (cf. point e)).
- 20 d) Sequencing of the alpha subunit
Several sequencing runs are performed using alpha subunit, carboxymethylated alpha subunit, or integral highly purified human uFSH usually loading 5 nmoles or less into the protein sequencer (470 A,
25 Applied Biosystem) and using the standard 03RPTH program delivered by Applied Biosystem or a special program where cycles which cleave a Pro or a Gly are substituted by the special cycle 03CPRO. The first 45 residues starting from NH_2 terminal
30 of the molecule were identified and the results confirm the amino acid sequence known from the literature (J. Biol. Chem. 250, 6735 (1975). The Asn at position 52 and at position 78 referring to the known sequence starting with Ala are the
35 amino acids where glycosylation occurs. At the NH_2 terminal is always present an heterogeneity and is always the same in all samples

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sequenced. The complete molecule (i.e. starting with Ala) is present in 65% of the chains, the molecule missing the first two amino acids (i.e. starting with Asp) is present in 5%, the molecule missing the first three amino acids (i.e. starting with Val) is present in 30%.

	1		5
	65% of chains	Ala Pro Asp Val Gln	
	5% of chains	Asp Val Gln	
10	30% of chains	Val Gln	

Heterogeneity of alpha subunit.

e) Sequencing of the beta subunit

Several sequencing runs were performed using beta subunit, carboxymethylated beta subunits, integral highly purified human u-FSH and tryptic peptides from pyridylethylated beta subunit.

The samples were loaded into the protein sequencer (470 A, Applied Biosystem) using the standard 03RPTH program delivered by Applied Biosystem. The results show that that beta-subunit is 111 amino acids long and has the following amino acid sequence:

	10
25	Asn Ser Cys Glu Leu Thr Asn Ile Thr Ile Ala Ile
	20
	Glu Lys Glu Glu Cys Arg Phe Cys Ile Ser Ile Asn
	30
	Thr Thr Trp Cys Ala Gly Tyr Cys Tyr Thr Arg Asp
30	40
	Leu Val Tyr Lys Asp Pro Ala Arg Pro Lys Ile Gln
	50
	Lys Thr Cys Thr Phe Lys Glu Leu Val Tyr Glu Thr
	60
	70
35	Val Arg Val Pro Gly Cys Ala His His Ala Asp Ser
	80
	Leu Tyr Thr Tyr Pro Val Ala Thr Gln Cys His Cys

- 19 -

90

Gly Lys Cys Asp Ser Asp Ser Thr Asp Cys Thr Val
100

Arg Gly Leu Gly Pro Ser Tyr Cys Ser Phe Gly Glu
5 110
Met Lys Glu

The Asn at position 7 and 24 referring to the above
sequence starting with Asn at position 1 are the amino
10 acids where glycosilation occurs.

At the NH₂ terminal of beta subunit is always
present an heterogeneity and is always the same in all
samples sequenced. The complete molecule (i.e.
starting with Asn) is present in 35% of the chains,
15 the molecule missing the first amino acids (i.e.
starting with Ser) is present in 15%, the molecule
missing the first two amino acids (i.e. starting with
Cys) is present in 50%.

		1				5	
20	35% of chains	Asn	Ser	Cys	Gly	Leu
	15% of chains		Ser	Cys	Glu	Leu
	50% of chains			Cys	Gly	Leu

Heterogeneity of beta subunit.

25 EXAMPLE 3: Pharmaceutical preparations

The production of pharmaceutical dosage form
preparations containing hpuFSH obtained in accordance
with this invention is not particularly difficult.
30 Since the substance maintains its biological activity
after lyophilization, this is the preferred form for
injectable preparations.

The lyophilized hpuFSH-containing preparation is
reconstituted using physiological saline and/or other
35 suitable diluents to yield an injectable solution.

Some excipients may be suitably used in the
composition as a part thereof, such as, for example,

mannitol, lactose, glycine, glucose, saccharose and their mixtures. Other conventional carriers, fillers and the like can be used. Mixtures are operable.

In the experiments carried out according to the present invention, lactose has been used as the excipient for the injectable preparations.

In preparing injectable formulations, pH is optionally adjusted via the addition of conventional acidic or basic substances. Acidic substances include acetic acid and the like. Basic substances include sodium hydroxide and the like. Mixtures can be employed.

The use of one or more stabilizers, e.g. albumin and the like, is contemplated.

A typical example of pharmaceutical production for the manufacturing of a batch of 20,000 ampoules each containing 75 I.U. FSH is as follows.

The calculated (in units of biological activity) amount of the lyophilized FSH bulk powder is dissolved in 700 ml of cold apyrogenic water for injection. If necessary, pH is readjusted to a value between 6.2 and 6.8 by using either acetic acid or sodium hydroxide, as the case may be. The solution is then sterile filtered through a 0.2 micron pores filter.

200 grams of lactose are dissolved in 2 litres of apyrogenic water for injection, sterile filtered as above and added to the FSH solution.

Apyrogenic water for injection is added to reach a final volume of 15 litres, the solution is dispensed into ampoules (0.75 ml each) and lyophilized in a sterile lyophilizator.

Ampoules are obtained which contain each 75 I.U. FSH and 10 mg lactose.

In a preferred embodiment the ampoules may contain 150 I.U. FSH.

According to a further example of

pharmaceutical preparation, ampoules have been prepared which also contain 1 mg of human albumin as stabilizer in addition to the excipient lactose.

Although this invention has been illustrated
5 with specific examples, it is understood that variations may be made without departing from the spirit and scope of the invention.

Claims

- 1) A protein comprising an alpha- and a beta-subunit, wherein the alpha-subunit is a gonadotropin alpha-subunit and the beta-subunit has the following amino-acid sequence:
- 10
- Asn Ser Cys Glu Leu Thr Asn Ile Thr Ile Ala Ile Glu
- 20
- 10 Lys Glu Glu Cys Arg Phe Cys Ile Ser Ile Asn Thr Thr
- 30
- Trp Cys Ala Gly Tyr Cys Tyr Thr Arg Asp Leu Val Tyr
- 40 50
- Lys Asp Pro Ala Arg Pro Lys Ile Gln Lys Thr Cys Thr
- 60
- 15 Phe Lys Glu Leu Val Tyr Glu Thr Val Arg Val Pro Gly
- 70
- Cys Ala His His Ala Asp Ser Leu Tyr Thr Tyr Pro Val
- 80 90
- 20 Ala Thr Gln Cys His Cys Gly Lys Cys Asp Ser Asp Ser
- 100
- Thr Asp Cys Thr Val Arg Gly Leu Gly Pro Ser Tyr Cys
- 110
- Ser Phe Gly Glu Met Lys Glu
- 25
- 2) A protein according to claim 1 which further comprises a beta-subunit of 110 amino acids corresponding to the amino acid sequence as defined in claim 1 but lacking the starting Asn (position
- 30 1).
- 3) A protein according to claim 2 which further comprises a beta-subunit of 109 amino acids corresponding to the amino acid sequence as defined
- 35 in claim 1 but lacking the starting Asn and the Ser at position 2.

- 23 -

- 4) A protein according to claim 1 wherein the gonadotropin alpha-subunit has the following amino acid sequence:

10

5 Ala Pro Asp Val Gln Asp Cys Pro Glu Cys Thr Leu Gln
20
Glu Asn Pro Phe Phe Ser Gln Pro Gly Ala Pro Ile Leu
30
Gln Cys Met Gly Cys Cys Phe Ser Arg Ala Tyr Pro Thr
10 40 50
Pro Leu Arg Ser Lys Lys Thr Met Leu Val Gln Lys Asn
60
Val Thr Ser Glu Ser Thr Cys Cys Val Ala Lys Ser Tyr
70
15 Asn Arg Val Thr Val Met Gly Gly Phe Lys Val Glu Asn
80 90
His Thr Ala Cys His Cys Ser Thr Cys Tyr Tyr His Lys
Ser

20

- 5) A protein according to any of claims 1 to 4 which further comprises an alpha-subunit of 90 amino acids corresponding to the amino acid sequence as defined in claim 4 but lacking the starting Ala and the Pro at position 2.

25

- 6) A protein according to any of claims 1 to 5 which further comprises an alpha-subunit of 89 amino acids corresponding to the amino acid as defined in claim 4 but lacking the starting Ala, the Pro at position 2 and the Asp at position 3.

30

- 7) A protein according to any of claims 1 to 6 in glycosylated form.

35

- 8) A protein according to claim 7 wherein the Asn at position 7 and 24 of the beta-subunit(s)

- 24 -

and the Asn at position 52 and 78 of the
alpha-subunit(s) are glycosylated.

- 5 9) A protein according to claim 7, having
follicle stimulating hormone (FSH) biological
activity.
- 10 10) A protein according to any of claims 1 to 6
substantially free from detectable traces of
luteinizing hormone and other urinary proteins.
- 11) A protein according to claim 10 which is
extracted from human menopausal urine.
- 15 12) A biologically active urinary Follicle
Stimulating Hormone substantially free from
detectable traces of luteinizing hormone and other
urinary proteins.
- 20 13) A biologically active hormone according to
claim 12 containing a gonadotropin alpha-subunit
and a beta-subunit wherein the beta-subunit has
the same amino acid sequence as defined in claim 1.
- 25 14) A protein according to claim 9 or 12, having
a specific activity not lower than 6200 I.U. of
FSH per mg of lyophilized powder.
- 30 15) A process for preparing a protein according
to any of claims 1 to 14 characterized in that it
includes the steps of subjecting a post-menopausal
urinary concentrate to immunopurification using
FSH-specific immobilized monoclonal antibodies,
eluting to recover the FSH and removing any
35 residual traces of contaminants by reverse phase
HPLC.

- 25 -

- 16) The process of claim 15 characterized in that the starting material is Human Menopausal Gonadotropin.
- 5 17) The process of claim 15 or 16 characterized in that elution of FSH from the immunocomplex is carried out using as eluent an aqueous solution having a pH higher than about 10 and a molarity higher than about 0.5.
- 10 18) The process of claim 17 characterized in that the eluent has a pH comprised within the range of 11.3 to 11.7 and a molarity of about 1.
- 15 19) The process of claim 18 characterized in that the eluent is 1 M ammonia.
- 20 20) A pharmaceutical preparation containing a therapeutically effective amount of a protein according to any of claims 1 to 14.
- 21) A pharmaceutical preparation according to claim 20 comprising a suitable excipient.
- 25 22) A pharmaceutical preparation according to claim 21 wherein the excipient is lactose.
- 23) An injectable lyophilized pharmaceutical preparation according to any of claims 20 to 22.
- 30 24) A pharmaceutical preparation according to any of claims 20 to 23 adapted for subcutaneous administration.
- 35 25) A pharmaceutical preparation as claimed in claim 20 which contains about 75 I.U. of FSH per ampoule.

- 26 -

- 26) A pharmaceutical preparation as claimed in claim 20 which contains about 150 I.U. of FSH per ampoule.
- 5 27) A pharmaceutical preparation as claimed in any of claims 20 to 26 comprising human albumin as stabilizer.
- 10 28) The use of a protein according to any of claims 1 - 14 in the preparation of a pharmaceutical preparation according to claim 20.

Fig. 1 SDS-PAGE

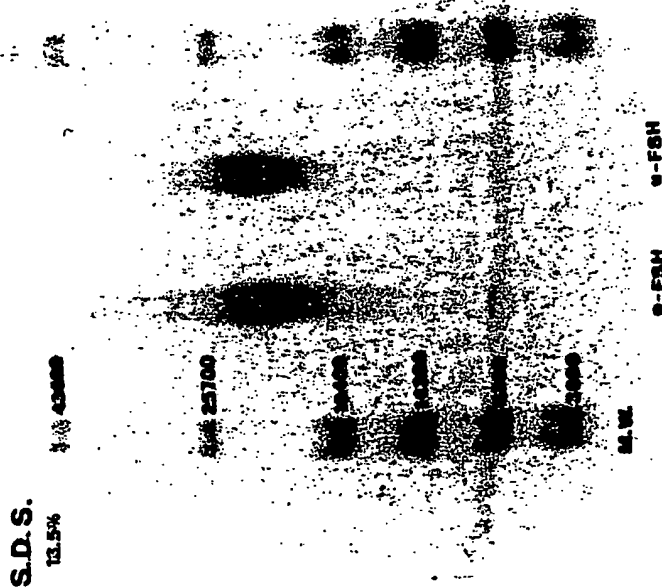


Fig. 3 Isoelectrofocusing

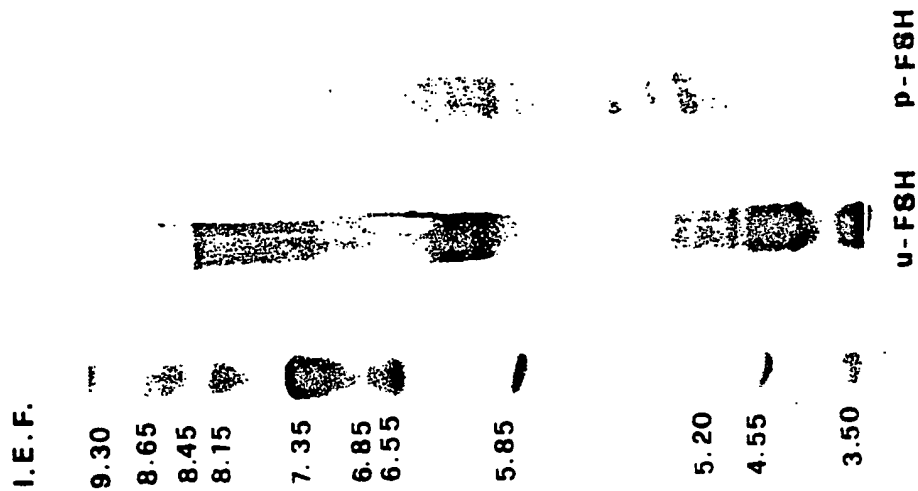
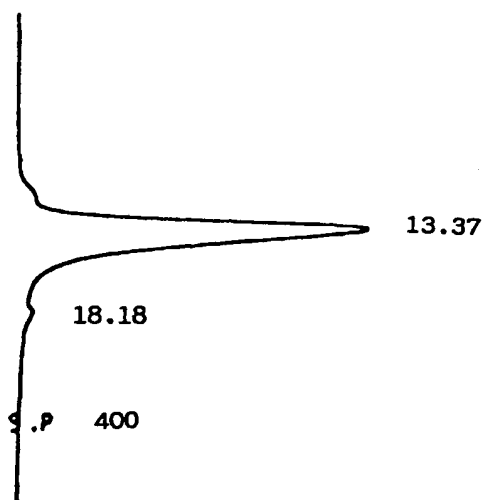
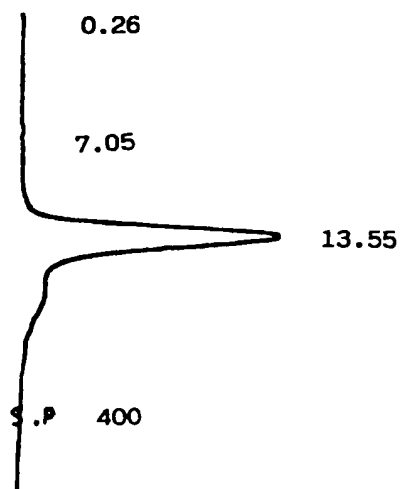


Fig.2 Size exclusion chromatography

uFSH




pFSH



INTERNATIONAL SEARCH REPORT

International Application No PCT/IT 88/00048

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC C 07 K 13/00; IPC ⁴ : C 12 P 21/02; C 07 K 7/10; // A 61 K 37/38; C 07 K 3/20		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	C 07 K 13/00; C 07 K 7/00; C 07 K 3/00; C 12 P 21/00; A 61 K 37/00	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	WO, A, 86/04589 (V.B. REDDY et al.) 14 August 1986, see page 10 --	1,4,7-9,20
X	The Journal of Biological Chemistry, vol. 250, no. 17, 10 September 1975, (US), P. Rathnam et al.: "Primary amino acid sequence of follicle-stimulating hormone from human pituitary glands", pages 6735-6746, see page 6740, figure 7 --	1,4,7-9
X	Endocrine Reviews, vol. 4, no. 2, 1983, The Endocrine Society (US), S.C. Chappel et al.: "Biosynthesis and secretion of follicle-stimulating hormone", pages 179-211, see page 181, column 1 cited in the application --	1,4,7-9
Y	GB, A, 2173803 (PUBLIC HEALTH LABORATORY SERVICE BOARD U.K.) 22 October 1986, see the whole document cited in the application --	15
	./.	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
15th September 1988	19. 10. 88	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 P.C.G. VAN DER PUTTEN	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	Journal of Liquid Chromatography, vol. 9, no. 13, 1986, Marcel Dekker, Inc., P. Hallin et al.: "Preservation of biological LH and FSH activity after application on HPLC. Comparison between cation-exchange and reverse-phase high performance liquid chromatography", pages 2855-2868, see the whole document cited in the application	15
A	Chemical Abstracts, vol. 81, 1974, (Columbus, Ohio, US), C.H. Mortimer et al.: "Intravenous, intramuscular, subcutaneous and intranasal administration of LH/FSH-RH(LH/FSH-releasing hormone). Duration of effect and occurrence of asynchronous pulsatile release of LH and FSH", see page 22, abstract no. 33814u, & Clin. Endocrinol.(Oxford) 1974, 3(1), 19-25	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

IT 8800048
SA 22958

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 11/10/88
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A- 8604589	14-08-86	EP-A- 0211894 JP-T- 63500212	04-03-87 28-01-88
GB-A- 2173803	22-10-86	None	